

Supplemental Digital Content 7A: Comparative Acute Kidney Injury Risk Model Performance with Inclusion of Absolute Intraoperative Hypotension Measures – Logistic Regression Full Model[†] Performed on Derivation Cohort

Risk Factor	β Coefficient	Multivariable model p-value	Adjusted Odds Ratio (95% Confidence Interval)
Medical Factors			
Patient Age (years) [§]	0.0000134	0.18	1.00 (0.99-1.00)
BMI (kg/m ²) ^{§§}	0.181	<0.001	1.20 (1.16-1.24)
Male Gender	0.305	<0.001	1.36 (1.28-1.44)
Patient Medical History *			
Congestive Heart Failure	0.051	0.28	1.05 (0.96-1.15)
Cardiac Arrhythmias	0.085	0.03	1.09 (1.01-1.17)
Valvular Disease	-0.022	0.69	0.98 (0.88-1.09)
Pulmonary Circulation Disorders	0.153	0.01	1.17 (1.04-1.30)
Peripheral Vascular Disorders	0.059	0.15	1.06 (0.98-1.15)
Hypertension, Uncomplicated	0.012	0.72	1.01 (0.95-1.08)
Hypertension, Complicated	0.557	<0.001	1.75 (1.59-1.92)
Paralysis/Other Neurological Disorders	0.107	0.03	1.11 (1.01-1.23)
Chronic Pulmonary Disease	0.009	0.81	1.01 (0.94-1.09)
Diabetes, Uncomplicated	0.055	0.14	1.06 (0.98-1.14)
Diabetes, Complicated	0.394	<0.001	1.48 (1.27-1.73)
Hypothyroidism	-0.084	0.07	0.92 (0.84-1.01)
Liver Disease	0.470	<0.001	1.60 (1.46-1.75)
Peptic Ulcer Disease Excluding Bleeding	0.026	0.79	1.03 (0.85-1.24)
AIDS/HIV	0.445	0.10	1.56 (0.92-2.63)
Rheumatoid Arthritis / Collagen Vascular Diseases	-0.056	0.45	0.95 (0.82-1.09)
Coagulopathy	0.400	<0.001	1.49 (1.36-1.64)
Lymphoma	0.124	0.21	1.13 (0.93-1.38)
Metastatic Cancer	0.010	0.84	1.01 (0.91-1.12)
Solid Tumor	-0.022	0.61	0.98 (0.90-1.06)
Weight Loss	0.176	<0.001	1.19 (1.09-1.30)
Alcohol Abuse	-0.151	0.03	0.86 (0.75-0.99)
Drug Abuse	-0.032	0.72	0.97 (0.82-1.15)
Psychoses	-0.072	0.56	0.93 (0.73-1.19)
Preoperative Chronic Medications			
ACEI/ARB	0.019	0.64	1.02 (0.94-1.11)
Beta Blocker	-0.027	0.47	0.97 (0.90-1.05)
Preoperative hemoglobin (g/dL) [§]	-0.006	<0.001	0.99 (0.99-0.99)
Preoperative eGFR (mL/min/1.73 m ²) ^{*** §}	-0.00002	<0.001	0.99 (0.99-0.99)
Preinduction Baseline Mean Arterial Pressure (mmHg) [§]	0.00002	<0.001	1.00002 (1.00001-1.00003)
Surgical Factors			
Surgical Body Region			
Elevated Risk (all regions except below)	0.846	<0.001	2.33 (2.11-2.57)
Emergent Surgery	0.347	<0.001	1.41 (1.29-1.55)
Anesthetic Factors			
ASA Class			
ASA Class 1	0		(reference)
ASA Class 2	0.062	0.62	1.06 (0.83-1.36)
ASA Class 3	0.759	<0.001	2.11 (1.66-2.69)
ASA Class 4	1.154	<0.001	3.17 (2.47-4.07)
ASA Class 5	1.858	<0.001	6.41 (4.35-9.45)
Expected Anesthesia Duration ^{§§§}	1.043	<0.001	2.84 (2.49-3.24)
General Anesthesia	0.281	<0.001	1.32 (1.21-1.45)
Institutional Factors			
Non-university Hospital (Fixed Effect)	-0.067	0.71	0.93 (0.65-1.34)
Institution (Random Effect), ICC (95% CI)			0.21 (0.11-0.38)
Intraoperative Hypotension – Absolute			
No Absolute Hypotension (>10 minutes)	0		(reference)
MAP 60-64 mmHg (>10 minutes)	0.101	0.007	1.11 (1.03-1.19)
MAP 55-59 mmHg (>10 minutes)	0.244	<0.001	1.28 (1.17-1.39)
MAP 50-54 mmHg (>10 minutes)	0.366	<0.001	1.44 (1.28-1.62)
MAP <50 mmHg (>10 minutes)	0.610	<0.001	1.84 (1.61-2.10)
Model performance <i>without</i> Absolute Intraoperative Hypotension Variables (c-statistic)			0.75 (0.74-0.76)

Model performance <i>with</i> Absolute Intraoperative Hypotension Variables (c-statistic)	0.75 (0.75-0.76)
Model performance <i>with</i> Absolute Intraoperative Hypotension Variables (net reclassification improvement)	0.092 (0.067-0.117)

† Mixed effects model with anonymized institution ID as random effect; all other covariates fixed effects.

* As determined by Elixhauser Comorbidity Enhanced ICD-9-CM/ICD-10 CM Algorithm

** As determined by CKD-EPI formula, indexed by body surface area. Race assumed non-black for patients with race data unavailable.

§ Squared transformation

§§ Square root transformation

§§§ Logarithmic transformation

ACEI = angiotensin-converting enzyme inhibitor; AIDS = autoimmune deficiency syndrome; AKI = acute kidney injury; ARB = angiotensin II receptor blocker; ASA = American Society of Anesthesiologists; CKD-EPI = Chronic Kidney Disease Epidemiology Collaboration; CPT = Current Procedural Terminology; eGFR = estimated glomerular filtration rate; HIV = human immunodeficiency virus; ICC = intraclass correlation coefficient; KDIGO = Kidney Disease: Improving Global Outcomes; WHO = World Health Organization

Log likelihood = -18,347.0

Supplemental Digital Content 7B: Comparative Acute Kidney Injury Risk Model Performance with Inclusion of Relative Intraoperative Hypotension Measures – Logistic Regression Full Model[†] Performed on Derivation Cohort

Risk Factor	β Coefficient	Multivariable model p-value	Adjusted Odds Ratio (95% Confidence Interval)
Medical Factors			
Patient Age (years) [§]	0.000011	0.28	1.00 (0.99-1.00)
BMI (kg/m ²) ^{§§}	0.179	<0.001	1.20 (1.15-1.24)
Male Gender	0.304	<0.001	1.35 (1.28-1.44)
Patient Medical History *			
Congestive Heart Failure	0.050	0.28	1.05 (0.96-1.15)
Cardiac Arrhythmias	0.082	0.03	1.09 (1.01-1.17)
Valvular Disease	-0.024	0.67	0.98 (0.88-1.09)
Pulmonary Circulation Disorders	0.147	0.01	1.16 (1.04-1.29)
Peripheral Vascular Disorders	0.061	0.13	1.06 (0.98-1.15)
Hypertension, Uncomplicated	0.010	0.78	1.01 (0.95-1.08)
Hypertension, Complicated	0.557	<0.001	1.75 (1.59-1.92)
Paralysis/Other Neurological Disorders	0.108	0.03	1.11 (1.01-1.23)
Chronic Pulmonary Disease	0.007	0.85	1.01 (0.94-1.09)
Diabetes, Uncomplicated	0.059	0.11	1.06 (0.99-1.14)
Diabetes, Complicated	0.400	<0.001	1.49 (1.28-1.74)
Hypothyroidism	-0.085	0.07	0.92 (0.84-1.01)
Liver Disease	0.469	<0.001	1.60 (1.46-1.75)
Peptic Ulcer Disease Excluding Bleeding	0.035	0.72	1.04 (0.86-1.25)
AIDS/HIV	0.425	0.11	1.53 (0.91-2.58)
Rheumatoid Arthritis / Collagen Vascular Diseases	-0.057	0.44	0.94 (0.82-1.09)
Coagulopathy	0.399	<0.001	1.49 (1.36-1.64)
Lymphoma	0.122	0.22	1.13 (0.93-1.37)
Metastatic Cancer	0.008	0.89	1.01 (0.91-1.12)
Solid Tumor	-0.022	0.61	0.98 (0.90-1.06)
Weight Loss	0.179	<0.001	1.20 (1.10-1.30)
Alcohol Abuse	-0.150	0.03	0.86 (0.75-0.99)
Drug Abuse	-0.035	0.69	0.97 (0.81-1.14)
Psychoses	-0.073	0.55	0.93 (0.73-1.18)
Preoperative Chronic Medications			
ACEI/ARB	0.021	0.62	1.02 (0.94-1.11)
Beta Blocker	-0.023	0.54	0.98 (0.91-1.05)
Preoperative hemoglobin (g/dL) [§]	-0.006	<0.001	0.99 (0.99-0.99)
Preoperative eGFR (mL/min/1.73 m ²) ^{*** §}	-0.00002	<0.001	0.99 (0.99-0.99)
Preinduction Baseline Mean Arterial Pressure (mmHg) [§]	-0.00002	0.003	0.99 (0.99-0.99)
Surgical Factors			
Surgical Body Region			
Elevated Risk (all regions except below)	0.855	<0.001	2.35 (2.13-2.59)
Emergent Surgery	0.352	<0.001	1.42 (1.30-1.56)
Anesthetic Factors			
ASA Class			
ASA Class 1	0		(reference)
ASA Class 2	0.061	0.63	1.06 (0.83-1.36)
ASA Class 3	0.741	<0.001	2.10 (1.65-2.67)
ASA Class 4	1.143	<0.001	3.14 (2.44-4.02)
ASA Class 5	1.863	<0.001	6.44 (4.37-9.50)
Expected Anesthesia Duration ^{§§§}	1.103	<0.001	3.01 (2.64-3.44)
General Anesthesia	0.270	<0.001	1.31 (1.20-1.44)
Institutional Factors			
Non-university Hospital (Fixed Effect)	-0.061	0.74	0.94 (0.66-1.34)
Institution (Random Effect), ICC (95% CI)			0.21 (0.11-0.38)
Intraoperative Hypotension - Relative			
No Relative Hypotension	0		(reference)
MAP 20-30% below baseline (>10 minutes)	-0.025	0.54	0.98 (0.90-1.06)
MAP 30-40% below baseline (>10 minutes)	0.105	0.02	1.11 (1.02-1.21)
MAP \geq 40% below baseline (>10 minutes)	0.380	<0.001	1.46 (1.31-1.63)
Model performance <i>without</i> Relative Intraoperative Hypotension Variables (c-statistic)			0.75 (0.74-0.76)
Model performance <i>with</i> Relative Intraoperative Hypotension Variables (c-statistic)			0.75 (0.75-0.76)

Model performance <i>with</i> Relative Intraoperative Hypotension Variables (net reclassification improvement)	0.124 (0.098-0.150)
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† Mixed effects model with anonymized institution ID as random effect; all other covariates fixed effects.

* As determined by Elixhauser Comorbidity Enhanced ICD-9-CM/ICD-10 CM Algorithm

** As determined by CKD-EPI formula, indexed by body surface area. Race assumed non-black for patients with race data unavailable.

§ Squared transformation

§§ Square root transformation

§§§ Logarithmic transformation

ACEI = angiotensin-converting enzyme inhibitor; AIDS = autoimmune deficiency syndrome; AKI = acute kidney injury; ARB = angiotensin II receptor blocker; ASA = American Society of Anesthesiologists; CKD-EPI = Chronic Kidney Disease Epidemiology Collaboration; CPT = Current Procedural Terminology; eGFR = estimated glomerular filtration rate; HIV = human immunodeficiency virus; ICC = intraclass correlation coefficient; KDIGO = Kidney Disease: Improving Global Outcomes; WHO = World Health Organization

Log likelihood = -18,366.23

Supplemental Digital Content 7C: Comparative Acute Kidney Injury Risk Model Performance with Inclusion of Absolute Intraoperative Hypotension Measures – Logistic Regression Full Model[†] Performed on Validation Cohort

Risk Factor	β Coefficient	Multivariable model p-value	Adjusted Odds Ratio (95% Confidence Interval)
Medical Factors			
Patient Age (years) [§]	0.000036	0.011	1.00 (1.00-1.00)
BMI (kg/m ²) ^{§§}	0.197	<0.001	1.22 (1.15-1.28)
Male Gender	0.342	<0.001	1.41 (1.30-1.53)
Patient Medical History *			
Congestive Heart Failure	0.101	0.121	1.11 (0.97-1.26)
Cardiac Arrhythmias	0.054	0.313	1.06 (0.95-1.17)
Valvular Disease	-0.109	0.160	0.90 (0.77-1.04)
Pulmonary Circulation Disorders	0.164	0.037	1.18 (1.01-1.37)
Peripheral Vascular Disorders	0.034	0.542	1.03 (0.93-1.15)
Hypertension, Uncomplicated	0.027	0.552	1.03 (0.94-1.13)
Hypertension, Complicated	0.663	<0.001	1.88 (1.65-2.15)
Paralysis/Other Neurological Disorders	0.040	0.579	1.04 (0.90-1.20)
Chronic Pulmonary Disease	0.104	0.048	1.11 (1.00-1.23)
Diabetes, Uncomplicated	0.044	0.394	1.05 (0.94-1.16)
Diabetes, Complicated	0.497	<0.001	1.64 (1.34-2.01)
Hypothyroidism	-0.038	0.555	0.96 (0.85-1.09)
Liver Disease	0.487	<0.001	1.63 (1.43-1.85)
Peptic Ulcer Disease Excluding Bleeding	-0.084	0.548	0.92 (0.70-1.21)
AIDS/HIV	-0.409	0.444	0.66 (0.23-1.89)
Rheumatoid Arthritis / Collagen Vascular Diseases	-0.174	0.110	0.84 (0.68-1.04)
Coagulopathy	0.250	<0.001	1.28 (1.12-1.47)
Lymphoma	0.056	0.703	1.05 (0.79-1.41)
Metastatic Cancer	0.042	0.566	1.04 (0.90-1.20)
Solid Tumor	-0.087	0.150	0.92 (0.81-1.03)
Weight Loss	0.090	0.162	1.09 (0.96-1.24)
Alcohol Abuse	-0.240	0.019	0.79 (0.64-0.96)
Drug Abuse	0.046	0.707	1.05 (0.83-1.33)
Psychoses	0.083	0.620	1.09 (0.78-1.51)
Preoperative Chronic Medications			
ACEI/ARB	0.056	0.326	1.06 (0.95-1.18)
Beta Blocker	0.057	0.282	1.06 (0.95-1.17)
Preoperative hemoglobin (g/dL) [§]	-0.006	<0.001	0.99 (0.99-0.99)
Preoperative eGFR (mL/min/1.73 m ²) ^{§§§}	-0.00003	<0.001	0.99 (0.99-0.99)
Preinduction Baseline Mean Arterial Pressure (mmHg) [§]	0.00003	<0.001	1.00 (1.00-1.00)
Surgical Factors			
Surgical Body Region			
Elevated Risk (all regions except below)	0.865	<0.001	2.37 (2.08-2.72)
Emergent Surgery	0.248	<0.001	1.28 (1.30-1.56)
Anesthetic Factors			
ASA Class			
ASA Class 1	0		(reference)
ASA Class 2	0.252	0.164	1.29 (0.90-1.84)
ASA Class 3	0.726	<0.001	2.07 (1.45-2.94)
ASA Class 4	1.219	<0.001	3.38 (2.35-4.86)
ASA Class 5	1.602	<0.001	4.96 (2.83-8.71)
Expected Anesthesia Duration ^{§§§}	1.283	<0.001	3.61 (2.99-4.35)
General Anesthesia	0.373	<0.001	1.45 (1.27-1.66)
Institutional Factors			
Non-university Hospital (Fixed Effect)	-0.197	0.324	0.82 (0.55-1.21)
Institution (Random Effect), ICC (95% CI)			0.21 (0.11-0.40)
Intraoperative Hypotension - Relative			
No Absolute Hypotension (>10 minutes)	0		(reference)
MAP 60-64 mmHg (>10 minutes)	0.459	<0.001	1.58 (0.90-1.06)
MAP 55-59 mmHg (>10 minutes)	0.390	<0.001	1.48 (1.02-1.21)
MAP 50-54 mmHg (>10 minutes)	0.194	0.001	1.21
MAP <50 mmHg (>10 minutes)	0.138	0.007	1.15 (1.31-1.63)
Model performance <i>without</i> Absolute Intraoperative Hypotension Variables (c-statistic)			0.75 (0.74-0.76)

Model performance <i>with</i> Absolute Intraoperative Hypotension Variables (c-statistic)	0.75 (0.75-0.76)
Model performance <i>with</i> Absolute Intraoperative Hypotension Variables (net reclassification improvement)	0.078 (0.042-0.115)

† Mixed effects model with anonymized institution ID as random effect; all other covariates fixed effects.

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** As determined by CKD-EPI formula, indexed by body surface area. Race assumed non-black for patients with race data unavailable.

§ Squared transformation

§§ Square root transformation

§§§ Logarithmic transformation

ACEI = angiotensin-converting enzyme inhibitor; AIDS = autoimmune deficiency syndrome; AKI = acute kidney injury; ARB = angiotensin II receptor blocker; ASA = American Society of Anesthesiologists; CKD-EPI = Chronic Kidney Disease Epidemiology Collaboration; CPT = Current Procedural Terminology; eGFR = estimated glomerular filtration rate; HIV = human immunodeficiency virus; ICC = intraclass correlation coefficient; KDIGO = Kidney Disease: Improving Global Outcomes; WHO = World Health Organization

Log likelihood = -9,451

Supplemental Digital Content 7D: Comparative Acute Kidney Injury Risk Model Performance with Inclusion of Relative Intraoperative Hypotension Measures – Logistic Regression Full Model[†] Performed on Validation Cohort

Risk Factor	β Coefficient	Multivariable model p-value	Adjusted Odds Ratio (95% Confidence Interval)
Medical Factors			
Patient Age (years) [§]	0.000033	0.019	1.00 (1.00-1.00)
BMI (kg/m ²) ^{§§}	0.194	<0.001	1.21 (1.15-1.28)
Male Gender	0.342	<0.001	1.41 (1.30-1.53)
Patient Medical History *			
Congestive Heart Failure	0.102	0.117	1.11 (0.97-1.26)
Cardiac Arrhythmias	0.052	0.331	1.05 (0.95-1.17)
Valvular Disease	-0.115	0.140	0.89 (0.77-1.04)
Pulmonary Circulation Disorders	0.165	0.036	1.18 (1.01-1.38)
Peripheral Vascular Disorders	0.035	0.526	1.04 (0.93-1.15)
Hypertension, Uncomplicated	0.026	0.569	1.03 (0.94-1.12)
Hypertension, Complicated	0.633	<0.001	1.88 (1.65-2.15)
Paralysis/Other Neurological Disorders	0.039	0.586	1.04 (0.90-1.20)
Chronic Pulmonary Disease	0.102	0.051	1.11 (1.00-1.23)
Diabetes, Uncomplicated	0.045	0.388	1.05 (0.95-1.16)
Diabetes, Complicated	0.501	<0.001	1.65 (1.35-2.02)
Hypothyroidism	-0.037	0.562	0.96 (0.85-1.09)
Liver Disease	0.491	<0.001	1.63 (1.44-1.85)
Peptic Ulcer Disease Excluding Bleeding	-0.087	0.531	0.92 (0.70-1.20)
AIDS/HIV	-0.384	0.473	0.68 (0.24-1.94)
Rheumatoid Arthritis / Collagen Vascular Diseases	-0.179	0.100	0.84 (0.68-1.04)
Coagulopathy	0.250	<0.001	1.28 (1.12-1.47)
Lymphoma	0.043	0.767	1.04 (0.79-1.39)
Metastatic Cancer	0.047	0.526	1.05 (0.91-1.21)
Solid Tumor	-0.091	0.133	0.91 (0.81-1.03)
Weight Loss	0.100	0.129	1.10 (0.97-1.25)
Alcohol Abuse	-0.240	0.018	0.79 (0.64-0.96)
Drug Abuse	0.034	0.781	1.03 (0.82-1.31)
Psychoses	0.082	0.622	1.09 (0.78-1.51)
Preoperative Chronic Medications			
ACEI/ARB	0.057	0.319	1.06 (0.95-1.18)
Beta Blocker	0.055	0.299	1.06 (0.95-1.17)
Preoperative hemoglobin (g/dL) [§]	-0.006	<0.001	0.99 (0.99-0.99)
Preoperative eGFR (mL/min/1.73 m ²) ^{*** §}	-0.0003	<0.001	0.99 (0.99-0.99)
Preinduction Baseline Mean Arterial Pressure (mmHg) [§]	-0.00000677	0.460	1.00 (1.00-1.00)
Surgical Factors			
Surgical Body Region			
Elevated Risk (all regions except below)	0.866	<0.001	2.38 (2.08-2.72)
Emergent Surgery	0.255	<0.001	1.29 (1.13-1.47)
Anesthetic Factors			
ASA Class			
ASA Class 1	0		(reference)
ASA Class 2	0.249	0.170	1.28 (0.90-1.83)
ASA Class 3	0.719	<0.001	2.05 (1.44-2.92)
ASA Class 4	1.206	<0.001	3.34 (2.32-4.80)
ASA Class 5	1.608	<0.001	4.99 (2.85-8.76)
Expected Anesthesia Duration ^{§§§}	1.332	<0.001	3.79 (3.14-4.57)
General Anesthesia	0.359	<0.001	1.43 (1.25-1.64)
Institutional Factors			
Non-university Hospital (Fixed Effect)	-0.197	0.325	0.82 (0.55-1.22)
Institution (Random Effect), ICC (95% CI)			0.21 (0.11-0.40)
Intraoperative Hypotension - Relative			
No Relative Hypotension	0		(reference)
MAP 20-30% below baseline (>10 minutes)	-0.012	0.829	0.99 (0.88-1.11)
MAP 30-40% below baseline (>10 minutes)	0.121	0.052	1.13 (0.99-1.28)
MAP \geq 40% below baseline (>10 minutes)	0.339	<0.001	1.40 (1.21-1.63)
Model performance <i>without</i> Relative Intraoperative Hypotension Variables (c-statistic)			0.75 (0.74-0.76)
Model performance <i>with</i> Relative Intraoperative Hypotension Variables (c-statistic)			0.75 (0.74-0.76)

Model performance <i>with</i> Relative Intraoperative Hypotension Variables (net reclassification improvement)	0.132 (0.095-0.168)
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† Mixed effects model with anonymized institution ID as random effect; all other covariates fixed effects.

* As determined by Elixhauser Comorbidity Enhanced ICD-9-CM/ICD-10 CM Algorithm

** As determined by CKD-EPI formula, indexed by body surface area. Race assumed non-black for patients with race data unavailable.

§ Squared transformation

§§ Square root transformation

§§§ Logarithmic transformation

ACEI = angiotensin-converting enzyme inhibitor; AIDS = autoimmune deficiency syndrome; AKI = acute kidney injury; ARB = angiotensin II receptor blocker; ASA = American Society of Anesthesiologists; CKD-EPI = Chronic Kidney Disease Epidemiology Collaboration; CPT = Current Procedural Terminology; eGFR = estimated glomerular filtration rate; HIV = human immunodeficiency virus; ICC = intraclass correlation coefficient; KDIGO = Kidney Disease: Improving Global Outcomes; WHO = World Health Organization

Log likelihood = -9,457.37